

CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

1. (Currently Amended) A computer system that enforces user specified currency constraints on a query on a database system having a query optimizer, a query processing engine and one or more local replicas of data in remote data sources, the computer system comprising:

at least one memory; and

at least one processing unit, comprising:

a constraint parser that interprets and converts the user specified currency constraints into [[a]] forms usable by the query optimizer, wherein at least one individual user specified currency constraint includes a consistency constraint and the constraint parser parses the consistency constraint;

a query plan generator that constructs a query plan for executing the query, wherein the query plan includes one or more subplan selection operators that check a currency of an individual local replica against the at least one individual user specified currency constraint and selects the-a subplan using the individual local replica only when the at least one individual user specified currency constraint is met; and

wherein the query processing engine executes the query plan, including the one or more subplan selection operators, thereby producing a result that satisfies the query's currency constraints; and

a heartbeat mechanism that includes a global heartbeat table and local replicated heartbeat tables that keep track of at least one individual local replica's currency.

2. (Currently Amended) The computer system of claim 1 comprising a currency constraint normalizer that resolves a plurality of the user-specified currency constraints into a single constraint representing a least upper bound of the plurality of the user specified currency constraints.

3. (Currently Amended) The computer system of claim 1 wherein tables in the individual local replica are grouped into currency regions and wherein the data in all-tables in a currency group correspond to the_a same database state.

4. (Canceled)

5. (Previously Presented) The computer system of claim 1 wherein a data source selection operator accesses a local heartbeat table to determine whether the currency of the local replica meets the at least one individual user specified currency constraint.

6. (Currently Amended) The computer system of claim 1 wherein the query optimizer estimates a cost associated with the query plan or at least one other query plan to be executed using athe individual local replica based on a probability that the individual local replica will meet the at least one individual user specified currency constraint.

7. (Canceled)

8. (Currently Amended) The computer system of claim 1 wherein the query plan generator verifies possible query plans against the at least one individual user specified consistency constraint and rejects individual possible

query plans that do not meet the consistency constraint.

9. (Currently Amended) The computer system of claim 1 comprising a consistency constraint normalizer that resolves a plurality of consistency constraints comprising the consistency constraint and one or more other consistency constraints into a single consistency constraint representing a least upper bound of the plurality of constraints.

10. (Canceled)

11. (Currently Amended) The computer system of claim 8 wherein the query plan generator derives a delivered consistency property for the query plan or at least one other query plan based on physical operators in the query plan the or at least one other query plan and compares the delivered consistency with the query's consistency constraint.

12. (Currently Amended) The computer system of claim 8 wherein tables in the-a local data source are grouped into currency regions and wherein the query plan generator verifies that inputs in the query plan or at least one other query plan that must be consistent belong to the same currency region.

13. (Currently Amended) A method comprising:

parsing a user specified constraint associated with a query, wherein the user specified constraint comprises a currency constraint and a consistency constraint and is stored in a memory to interpret and convert the user specified constraint into a form usable by a query optimizer;

constructing query execution plans that include a subplan selection operator of a subplan that verifies a currency of a local replica against the currency constraint and selects the subplan using the local replica only when the local replica's data meets the currency constraint;

verifying the query execution plans against the consistency constraint and rejecting individual query execution plans that do not meet the consistency constraint; and

executing the query plan, including any the subplan selection operator, thereby producing a result that satisfies the currency constraint and the consistency constraint; and

maintaining global and locally replicated logs of an update status of individual currency regions associated with the local replica or at least one other local replica.

14. (Currently Amended) The method of claim 13 comprising resolving a plurality of currency and consistency constraints associated with the database query into a single currency and consistency constraint that represents a least upper bound of the plurality of currency and consistency constraints.

15. (Previously Presented) The method of claim 14 comprising grouping tables of the local replica or the at least one other local replica into the individual currency regions, wherein at least one individual currency region's one or more tables comprise data that corresponds to a same database state.

16. (Canceled)

17. (Previously Presented) The method of claim 15 wherein the subplan selection operator refers to information in a log to verify the currency of the local replica.

18. (Previously Presented) The method of claim 15 wherein possible query plans are evaluated by determining a delivered consistency based on physical operators that group input tables into sets of consistent input tables and verify that the input tables in a set of consistent input tables belong to a same currency region.

19. (Previously Presented) The method of claim 13 comprising estimating a cost associated with the query plan or another query plan to be executed using a certain local replica based on a probability that the certain local replica will meet the currency constraint of the query.

20. (Original) Computer-readable media comprising computer-executable instructions for performing the method of claim 13.

21. (Currently Amended) One or more computer readable media comprising computer-executable instructions for enforcing individual-user specified currency constraints on a query on a database system, wherein the database system has local replicas of data in remote data sources, the computer-executable instructions comprising:

interpreting and converting ~~a—an individual user~~ specified currency constraint into a form usable by a query optimizer, wherein the individual user specified currency constraint includes a consistency constraint;

parsing the consistency constraint;

constructing a query plan for executing the query, wherein the query plan includes a subplan selection operator that checks a currency of a local replica against the individual user specified currency constraint and selects a subplan using the local replica when the individual user specified currency constraint is met;

executing the query plan, including the subplan selection operator, thereby producing a result that satisfies the individual user specified currency constraint; and

grouping tables in local data sources into currency regions, wherein individual tables within an associated currency region include data that corresponds to a same database state.

22. (Previously Presented) The one or more computer readable media of claim 21 wherein the computer-executable instructions further comprise resolving a plurality of currency constraints into a single constraint that represents a least upper bound of the plurality of currency constraints.

23. (Canceled)

24. (Previously Presented) The one or more computer readable media of claim 21 wherein the computer-executable instructions further comprise utilizing a heartbeat mechanism to maintain a global heartbeat table and local replicated heartbeat tables that track individual currencies of individual local replicas.

25. (Currently Amended) The one or more computer readable media of claim 24 wherein the subplan selection operator accesses an individual local replicated heartbeat table to determine whether an individual local data source's currency meets the individual user specified currency constraint.

26. (Currently Amended) The one or more computer readable media of claim 21 wherein the computer-executable instructions further comprise estimating a cost associated with the query plan or at least one other query plan to be executed using a certain local replica based on a probability that the certain local replica will meet the individual user specified currency constraint.

27. (Canceled)

28. (Currently Amended) The one or more computer readable media of claim 21 wherein the computer-executable instructions further comprise verifying possible query plans against the consistency constraint and rejecting one or more of the possible query plans that do not meet the consistency constraint.

29. (Previously Presented) The one or more computer readable media of claim 28 wherein the computer-executable instructions further comprise resolving a plurality of individual consistency constraints into a single consistency constraint that represents a least upper bound of the plurality of individual consistency constraints.

30. (Previously Presented) The one or more computer readable media of claim 21 wherein the computer-executable instructions comprise deriving a delivered consistency property for the query plan or at least one other query plan based on physical operators in the query plan or the at least one other query plan and comparing the delivered consistency property with the consistency constraint.

31. (Canceled)

32. (Currently Amended) An apparatus comprising:
- means for interpreting and converting a user specified currency constraint associated with a query into a form usable by a query optimizer, wherein the user specified currency constraint includes a consistency constraint;
- means for interpreting and converting the consistency constraint;
- means for constructing a query plan for executing the query, wherein the query plan includes a subplan selection operator that checks a currency of a local replica against the user specified query's currency constraint and selects the subplan using the local replica only when the user specified currency constraint is met;
- means for executing the query plan, including the subplan selection operator, thereby producing a result that satisfies the query's currency requirements; and
- means for grouping individual tables in local data sources into currency regions utilizing a heartbeat mechanism to maintain a global heartbeat table and local replicated heartbeat tables configured to track individual currencies of individual local replicas.

33. (Previously Presented) The apparatus of claim 32 further comprising means for resolving a plurality of currency constraints into a single constraint that represents a least upper bound of the plurality of currency constraints.

34. (Previously Presented) The apparatus of claim 32 wherein individual tables' data within a currency region corresponds to a same database state.

35. (Canceled)

36. (Currently Amended) The apparatus of claim 34 wherein the subplan

selection operator accesses at least one of the local replicated heartbeat tables or another local heartbeat table to determine whether a currency of an individual local data source meets the user specified currency constraint.

37. (Previously Presented) The apparatus of claim 32 further comprising means for estimating a cost associated with an individual query plan to be executed using the local replica or at least one other local replica based on a probability that the local replica or the at least one other local replica will meet the user specified currency constraint.

38. (Canceled)

39. (Previously Presented) The apparatus of claim 32 further comprising means for verifying possible query plans against the consistency constraint and rejecting query plans that do not meet the consistency constraint.

40. (Previously Presented) The apparatus of claim 39 further comprising means for resolving a plurality of consistency constraints into a single consistency constraint that represents a least upper bound of the plurality of consistency constraints.

41. (Previously Presented) The apparatus of claim 32 further comprising means for deriving a delivered consistency property for one or both of the query plan or at least one other query plan based on physical operators in the query plan or at least one other query plan and comparing the delivered consistency property with the query's consistency constraint.